IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application

Applicant(s): Khalil C. Haddad
Case: 1
Serial No.: 09/803,801
Filing Date: March 12, 2001
Group: 2611
Examiner: Jason M. Perilla

Title: Shortening Impulse Response Filter (SIRF) and Design Technique Therefor

---

REPLY BRIEF

Mail Stop Appeal Brief – Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Appellants hereby reply to the Examiner's Answer, mailed September 19, 2007 (referred to hereinafter as "the Examiner's Answer"), in an Appeal of the final rejection of claims 1-8, 10-16, 18-26, and 28 in the above-identified patent application.

REAL PARTY IN INTEREST

A statement identifying the real party in interest is contained in Appellant's Appeal Brief.

RELATED APPEALS AND INTERFERENCES

A statement identifying related appeals is contained in Appellant's Appeal Brief.

STATUS OF CLAIMS

The present application was filed on March 12, 2001 with claims 1 through 28. Claims 9, 17, and 27 were cancelled in the Amendment and Response to Office Action dated

September 17, 2004. Claims 1-8, 10-16, 18-26, and 28 are presently pending in the above-identified patent application. Claims 1, 2, 4-6, 10-12, 14-16, and 18 are rejected under 35 U.S.C. §103(a) as being unpatentable over Nedic et al. (United States Patent Number 6,563,841; hereinafter "Nedic") in view of Haddad et al. ("Design of Digital Linear-Phase FIR Crossover Systems of Loudspeakers by the Method of Vector Space Projections," Haddad, Khalil C. et al.; hereinafter "Haddad"), claims 19, 20, 22-24, and 28 are rejected under 35 U.S.C. §103(a) as being unpatentable over Nedic in view of Haddad, and in further view of Gandhi et al. (United States Patent Number 6,112,218; hereinafter "Gandhi"), and claims 3, 7, 8, 13, 21, 25, and 26 are rejected under 35 U.S.C. §103(a) as being unpatentable over Nedic in view of Haddad, and further in view of Khalil C. ("Constrained FIR Filter Design by the Method of Vector Space Projections," Haddad, Khalil C. et al.; hereinafter "Khalil").

Claims 1, 7, 8, 10, 11, 18, 19, 25, 26, and 28 are being appealed.

STATUS OF AMENDMENTS

A statement identifying the status of the amendments is contained in Appellant's Appeal Brief.

SUMMARY OF CLAIMED SUBJECT MATTER

A Summary of the Invention is contained in Appellant's Appeal Brief.

STATEMENT OF GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

Claims 1, 2, 4-6, 10-12, 14-16, and 18 are rejected under 35 U.S.C. §103(a) as being unpatentable over Nedic et al. in view of Haddad et al., claims 19, 20, 22-24, and 28 are rejected under 35 U.S.C. §103(a) as being unpatentable over Nedic in view of Haddad, and in further view of Gandhi et al., and claims 3, 7, 8, 13, 21, 25, and 26 are rejected under 35 U.S.C. §103(a) as being unpatentable over Nedic in view of Haddad, and further in view of Khalil.

CLAIMS APPEALED

A copy of the appealed claims is contained in an Appendix of Appellant's Appeal Brief.

ARGUMENT

Response to Examiner's Answer

The Examiner asserts that "Applicant's argument is flawed in that it suggests that *each reference of a combination must contain every limitation of the claims*." (Page 12, 2nd paragraph; emphasis added.)

Contrary to the Examiner's assertion, Appellants have made *no* suggestion that each reference must contain every limitation. Rather, Appellants maintain that a person of ordinary skill in the art would find *no* suggestion to apply Haddad's VSPM method in the design of a Shortened Impulse Response Filter.

The Examiner asserts that "the differences between the prior art reference Haddad and independent claims 1 and 11 is only an amorphous label." (Page 12, last paragraph.)

The Examiner has not clearly identified the alleged "amorphous label," but Appellants note that "amorphous" is defined as "lacking definite form." Clearly, the differences cited in Appellant's original arguments (see below) are definite in nature. Assuming the Examiner's "amorphous label" was intended to pertain to the differences between Finite Impulse Response (FIR) and Shortening Impulse Response Filters (SIRF) (as indicated on page 13, line 3), Appellants respectfully disagree. On page 13, the Examiner asserts that "the difference between an FIR and SIRF filter is... not due to any structure of the digital filter itself but rather can only be attributed to the selection of such filter's coefficients in as much as they alter the filter's response to an impulse input." The Examiner asserts that "an SIRF filter can be composed of an FIR filter having a particular set of coefficients is notoriously understood in the art" and that "Nedic's disclosure evidences the fact that Haddad's own 'FIR' filter could, in reality, be an SIRF filter depending upon the constraints it must satisfy."

The Examiner further acknowledges that "no specific motivation is provided in either of the disclosures of Nedic or Haddad to utilize Haddad's VSPM method to choose Nedic's FIR filter's coefficients to have properties which categorize it as a SIRF filter," but the Examiner asserts that no motivation is required. The Examiner asserts that it would have been obvious for one skilled in the art to apply Haddad's VSPM method in the design of any digital filter because Haddad's VSPM method of filter design is known and accepted in the art

Appellant notes that the *creation and selection of the proper constraints for <u>SIRF</u> filter design is <u>not</u> trivial and is <u>not</u> disclosed by the prior art.* The present specification teaches, for example, that

> the sets involved in designing the SIRF filter 120 in an exemplary embodiment are *(i) a time domain convex set, C_1, representing the filters with linear phase, (ii) <u>a frequency domain **non-convex** set, C_2, representing the non-linear phase filters with the appropriate constraints in the pass-band and stop-band</u>, (iii) a frequency domain convex set, C_3, representing the linear phase filters with the appropriate constraints in the pass-band and stop-band, (iv) a time domain convex set, C_4, representing all the filters of length N, and (v) a time domain convex set, C_5 (n), for a specific range of values of n, (application dependent).* Although $C_5(n)$ consists of numerous convex sets, it is referred to hereinafter as C_5. More specifically, C_5 represents additional constraints on the filter h in the time domain. Thus, the time domain sets, C_1, C_4 and C_5, are convex, while the frequency domain sets, C_2 and C_3, are convex or non-convex for filters with linear or non-linear phase, respectively. The optional frequency domain set, C_3, constrains the filter such that it will have linear phase.
>
> The sets may be defined mathematically as follows:
>
> $$C_1 \equiv \{\mathbf{h} \in R^N : h(n) = h(N-1-n), \text{ for } n = 0,1,\cdots,N-1\}.$$
>
> $$C_2 \equiv \left\{\begin{array}{l}\mathbf{h} \in R^N : 1-\alpha \le |H(\omega)| \le 1+\alpha \text{ for } \omega \in \Omega_p \\ \text{and } |H(\omega)| \le \beta \text{ for } \omega \in \Omega_s\end{array}\right\}.$$
>
> $$C_3 \equiv \left\{\begin{array}{l}\mathbf{h} \in R^N : 1-\alpha \le A(\omega) \le 1+\alpha \\ \text{and } \Phi(\omega) = -\omega(N-1)/2 \text{ for } \omega \in \Omega_p, \\ |H(\omega)| \le \beta \text{ for } \omega \in \Omega_s.\end{array}\right\}.$$
>
> $$C_4 \equiv \{\mathbf{h} \in R^N\}.$$
>
> $$C_5(n) \equiv \{\mathbf{h} \in R^N : \sigma_n \le (\mathbf{s} * \mathbf{h})_n \le \rho_n\} \quad (0<n<N+M-1)$$
>
> where the vector **s** referenced in the definition for the set, C_5, is the impulse response of the channel, $*$ denotes convolution, $(\mathbf{s} * \mathbf{h})_n$ denotes the response at time n, and σ_n and ρ_n represent the desired lower and upper bounds, respectively. M is the size of the discrete channel impulse response, s. R^N is the Hilbert space of dimension N.
>
> (Page 5, line 8, to page 6, line 5; emphasis added.)

Appellant notes that constraint C_2 is a *<u>non-convex</u> constraint.* Appellant notes that *<u>non-convex</u> constraints* are *not* disclosed by the prior art and that the constraint C_2 in particular is *not* disclosed by the prior art. While constraint C_2 is claimed in a dependent claim and is not recited in the independent claims, it is representative of the difficulty and novelty of creating the proper constraints to utilize the VSPM technique for the design of SIRF filters.

Appellant maintains that the application of the VSPM technique for SIRF filter design is *not* trivial and would *not* be obvious to a person of ordinary skill in the art.

Independent Claims 1 and 11

Independent claims 1 and 11 are rejected under 35 U.S.C §103(a) as being unpatentable over Nedic in view of Haddad. Regarding claim 1, the Examiner acknowledges that Nedic does not explicitly disclose a method of determining the values of the coefficients via vector space projection methods (VSPM), but asserts that Haddad teaches a method to solve a mathematical problem encompassing multiple constraints by vector space projection. The Examiner further asserts that, because a SIRF filter is a particular type of FIR filter, one skilled in the art would be motivated to use Haddad's exemplary coefficient determining method for SIRF filters as well as FIR filters

Appellant notes that the concept of sets, intersection of sets and projections, and the modeling of constraints with mathematical sets are ***not*** disclosed or suggested by Nedic. In SIRF filter design, constraints in the time domain are needed in general to prevent spectral nulls from showing up in the solution of the coefficients. Nedic does not disclose or suggest *determining an intersecting set of at least one set of defining constraints that a SIRF filter must satisfy in the time domain and at least one set of defining constraints that the SIRF filter must satisfy in the frequency domain by employing vector space projection methods.*

Appellant could also find no disclosure or suggestion in any of the cited references to combine the SIRF design disclosed by Nedic with the method disclosed by Haddad. Independent claims 1 and 11 require establishing at least one set of defining constraints that said SIRF filter must satisfy in a time domain; establishing at least one set of defining constraints that said SIRF filter must satisfy in a frequency domain; and determining an intersecting set of said at least one set of defining constraints that said SIRF filter must satisfy in the time domain and said at least one set of defining constraints that said SIRF filter must satisfy in the frequency domain by employing vector space projection methods.

Thus, Nedic, Younce, Haddad, and Gandhi, alone or in any combination, do not disclose or suggest establishing at least one set of defining constraints that said SIRF filter must satisfy in a time domain; establishing at least one set of defining constraints that said SIRF filter

must satisfy in a frequency domain; and determining an intersecting set of said at least one set of defining constraints that said SIRF filter must satisfy in the time domain and said at least one set of defining constraints that said SIRF filter must satisfy in the frequency domain by employing vector space projection methods, as required by independent claims 1 and 11.

<u>Independent Claim 19</u>

Independent claim 19 is rejected under 35 U.S.C. §103(a) as being unpatentable over Nedic in view of Haddad, and in further view of Gandhi et al. As noted in rejecting claim 1, the Examiner acknowledges that Nedic does not explicitly disclose a method of determining the values of the coefficients via vector space projection methods (VSPM), but asserts that Haddad teaches a method to solve a mathematical problem encompassing multiple constraints by vector space projection. The Examiner further asserts that, because a SIRF filter is a particular type of FIR filter, one skilled in the art would be motivated to use Haddad's exemplary coefficient determining method for SIRF filters as well as FIR filters.

Appellant notes that the concept of sets, intersection of sets and projections, and the modeling of constraints with mathematical sets are ***not*** disclosed or suggested by Nedice. In SIRF filter design, constraints in the time domain are needed in general to prevent spectral nulls from showing up in the solution of the coefficients. Nedic does not disclose or suggest *determining an intersecting set of at least one set of defining constraints that a SIRF filter must satisfy in the time domain and at least one set of defining constraints that the SIRF filter must satisfy in the frequency domain by employing vector space projection methods*.

Appellant could also find no disclosure or suggestion in any of the cited references to combine the SIRF design disclosed by Nedic with the method disclosed by Haddad. Independent claim 19 requires establishing at least one set of defining constraints that said SIRF filter must satisfy in a time domain; establishing at least one set of defining constraints that said SIRF filter must satisfy in a frequency domain; and determining an intersecting set of said at least one set of defining constraints that said SIRF filter must satisfy in the time domain and said at least one set of defining constraints that said SIRF filter must satisfy in the frequency domain by employing vector space projection methods.

Thus, Nedic, Younce, Haddad, and Gandhi, alone or in any combination, do not disclose or suggest establishing at least one set of defining constraints that said SIRF filter must

satisfy in a time domain; establishing at least one set of defining constraints that said SIRF filter must satisfy in a frequency domain; and determining an intersecting set of said at least one set of defining constraints that said SIRF filter must satisfy in the time domain and said at least one set of defining constraints that said SIRF filter must satisfy in the frequency domain by employing vector space projection methods, as required by independent claim 19.

Additional Cited References

Khalil was also cited by the Examiner for its disclosure of a VSPM method wherein a filter is designed having an arbitrary magnitude and phase response.

Appellant notes that Khalil was published in August, 2000, and therefore does not constitute prior art under 35 U.S.C. §103(a) since the present application has a filing date of March 12, 2001 (Khalil is incorporated by reference in the present specification). In any case, Khalil is directed to *FIR* filter design and does ***not*** address the design of *SIRF* filters. In addition, the present specification teaches that,

> traditionally, VSPM techniques have been employed to design ***constrained FIR filters*** that are tailored to specific applications. See, K.C. Haddad, "Constrained FIR Filter Design by the Method of Vector Space Projections," IEEE Trans. on Circuit and Systems II: Analog and Digital Signal Processing, Vol. 47, No. 8 (Aug. 2000), incorporated by reference herein. In the context of the present invention, where VSPM techniques are employed to design an ***SIRF*** *filter*, ***two (or more) convex sets*** *representing the constraints in time and frequency domains and corresponding projection operators have been mathematically formulated.* A first convex set defines the constraints that the SIRF filter 120 must satisfy in the time domain, such that when the filter is convolved with the impulse response, the impulse response is shortened. Likewise, a second convex set defines the constraints that the SIRF filter 120 must satisfy in the frequency domain, such as a low, high or band pass band. P_i is defined to be the projection operator onto the set C_i. Thus, to obtain an SIRF filter satisfying both frequency and time constraints, an intersection of both sets is required.
>
> (Page 4, lines 13-25; emphasis added.)

Khalil does not disclose or suggest ***two (or more) convex sets*** *representing the constraints in time and frequency domains for SIRF filter design.*

Thus, Khalil does not disclose or suggest establishing at least one set of defining constraints that said SIRF filter must satisfy in a time domain; establishing at least one set of defining constraints that said SIRF filter must satisfy in a frequency domain; and determining an intersecting set of said at least one set of defining constraints that said SIRF filter must satisfy in

the time domain and said at least one set of defining constraints that said SIRF filter must satisfy in the frequency domain by employing vector space projection methods, as required by independent claims 1, 11, and 19.

Claims 7 and 25

Claims 7 and 25 are rejected under 35 U.S.C. §103(a) as being unpatentable over Nedic in view of Haddad, and further in view of Kahlil. Regarding claim 7, the Examiner asserts that Khalil discloses the additional limitations of claim 7 (page 716, col. 1, lines 20-40; col. 2).

Appellants could find no disclosure or suggestion by Khalil that a set of defining constraints that the ***SIRF*** filter must satisfy in the frequency domain is defined as follows:

$$C_2 \equiv \begin{Bmatrix} \mathbf{h} \in R^N : 1-\alpha \le |H(\omega)| \le 1+\alpha \ \text{ for } \omega \in \Omega_p \\ \text{and } |H(\omega)| \le \beta \text{ for } \omega \in \Omega_s \end{Bmatrix}.$$

where h is the impulse response of length N of the SIRF filter that shortens the impulse response of a channel, ω is a frequency, α and β are error tolerance regions of frequency and time domain, respectively, H(ω) is the impulse response in the frequency domain, R^N is the Hilbert space of dimension N, Ω_p is the pass-band and Ω_s is the stop-band.

Thus, Nedic, Kapoor, Gandhi, Haddad, and Khalil, alone or in any combination, do not disclose or suggest wherein said at least one set of defining constraints that said SIRF filter must satisfy in the frequency domain is defined as follows:

$$C_2 \equiv \begin{Bmatrix} \mathbf{h} \in R^N : 1-\alpha \le |H(\omega)| \le 1+\alpha \ \text{ for } \omega \in \Omega_p \\ \text{and } |H(\omega)| \le \beta \text{ for } \omega \in \Omega_s \end{Bmatrix}.$$

where h is the impulse response of length N of the SIRF filter that shortens the impulse response of a channel, ω is a frequency, α and β are error tolerance regions of frequency and time domain, respectively, H(ω) is the impulse response in the frequency domain, R^N is the Hilbert space of dimension N, Ω_p is the pass-band and Ω_s is the stop-band, as required by claims 7 and 25.

Claims 8 and 26

Claims 8 was rejected under 35 U.S.C. §103(a) as being unpatentable over Nedic in view if Haddad, and further in view of Kahlil. Regarding claim 8, the Examiner asserts that Khalil discloses the additional limitations of claim 8 (page 716, col. 1, lines 20-40; col. 2).

Appellants could find no disclosure or suggestion by Khalil that a set of defining constraints that the ***SIRF*** filter must satisfy in the frequency domain is defined as follows:

$$C_3 \equiv \left\{ \begin{array}{l} \mathbf{h} \in R^N : 1-\alpha \le A(\omega) \le 1+\alpha \\ \text{and } \Phi(\omega) = -\omega(N-1)/2 \text{ for } \omega \in \Omega_p \\ |H(\omega)| \le \beta \text{ for } \omega \in \Omega_s \end{array} \right\}.$$

where h is the impulse response of length N of the SIRF filter that shortens the impulse response of a channel, ω is a frequency, α and β are error tolerance regions of frequency and time domain, respectively, H(ω) is the impulse response in the frequency domain, R^N is the Hilbert space of dimension N, Ω_p is the pass-band, Ω_s is the stop-band, $A(\omega) = \sum_0^{N/2-1} 2h(n)\cos\left[\left(n - \frac{N-1}{2}\right)\omega\right]$ and $\Phi(\omega) = -\frac{N-1}{2}\omega$, wherein Φ(ω) and $A(\omega)$ are independent filter characteristics and wherein Φ(ω) is a linear phase and $A(\omega)$ is an amplitude.

Thus, Nedic, Kapoor, Gandhi, Haddad, and Khalil, alone or in any combination, do not disclose or suggest wherein said at least one set of defining constraints that said SIRF filter must satisfy in the frequency domain is defined as follows:

$$C_3 \equiv \left\{ \begin{array}{l} \mathbf{h} \in R^N : 1-\alpha \le A(\omega) \le 1+\alpha \\ \text{and } \Phi(\omega) = -\omega(N-1)/2 \text{ for } \omega \in \Omega_p \\ |H(\omega)| \le \beta \text{ for } \omega \in \Omega_s \end{array} \right\}.$$

where h is the impulse response of length N of the SIRF filter that shortens the impulse response of a channel, ω is a frequency, α and β are error tolerance regions of frequency and time domain, respectively, H(ω) is the impulse response in the frequency domain, R^N is the Hilbert space of dimension N, Ω_p is the pass-band, Ω_s is the stop-band, $A(\omega) = \sum_0^{N/2-1} 2h(n)\cos\left[\left(n - \frac{N-1}{2}\right)\omega\right]$ and $\Phi(\omega) = -\frac{N-1}{2}\omega$, wherein Φ(ω) and $A(\omega)$ are independent filter characteristics and wherein Φ(ω) is a linear phase and $A(\omega)$ is an amplitude, as required by claims 8 and 26

Conclusion

The rejections of the independent claims under section 103 in view of Nedic, Gandhi, Khalil, and Haddad, alone or in combination, are therefore believed to be improper and should be withdrawn. The remaining rejected dependent claims are believed allowable for at least the reasons identified above with respect to the independent claims

The attention of the Examiner and the Appeal Board to this matter is appreciated

Respectfully submitted,

/Kevin M. Mason/

Date: November 19, 2007

Kevin M. Mason
Attorney for Applicant(s)
Reg. No. 36,597
Ryan, Mason & Lewis, LLP
1300 Post Road, Suite 205
Fairfield, CT 06824
(203) 255-6560

APPENDIX

1. A method for determining coefficient values for a shortening impulse response filter (SIRF), said method comprising the steps of:

establishing at least one set of defining constraints that said SIRF filter must satisfy in a time domain;

establishing at least one set of defining constraints that said SIRF filter must satisfy in a frequency domain; and

determining an intersecting set of said at least one set of defining constraints that said SIRF filter must satisfy in the time domain and said at least one set of defining constraints that said SIRF filter must satisfy in the frequency domain by employing vector space projection methods.

2. The method according to claim 1, wherein said at least one set of defining constraints that said SIRF filter must satisfy in the time domain define a filter having a linear phase response.

3. The method according to claim 1, wherein said at least one set of defining constraints that said SIRF filter must satisfy in the frequency domain define a filter having a non-linear phase response

4. The method according to claim 1, wherein the time domain constraints specify a shortening of a channel impulse response.

5. The method according to claim 1, wherein the frequency domain constraints include a frequency response for said SIRF filter that does not attenuate a received signal.

6. The method according to claim 1, wherein the frequency domain constraints include a pass-band for said SIRF filter.

7. The method according to claim 2, wherein said at least one set of defining constraints that the SIRF filter must satisfy in the frequency domain is defined as follows:

$$C_2 \equiv \left\{ \begin{array}{l} \mathbf{h} \in R^N : 1-\alpha \le |H(\omega)| \le 1+\alpha \text{ for } \omega \in \Omega_p \\ \text{and } |H(\omega)| \le \beta \text{ for } \omega \in \Omega_s \end{array} \right\}.$$

where h is the impulse response of length N of the SIRF filter that shortens the impulse response of a channel, ω is a frequency, α and β are error tolerance regions of frequency and time domain, respectively, H(ω) is the impulse response in the frequency domain, R^N is the Hilbert space of dimension N, Ω_p is the pass-band and Ω_s is the stop-band.

8. The method according to claim 3, wherein said at least one set of defining constraints that the SIRF filter must satisfy in the frequency domain is defined as follows:

$$C_3 \equiv \left\{ \begin{array}{l} \mathbf{h} \in R^N : 1-\alpha \le A(\omega) \le 1+\alpha \\ \text{and } \Phi(\omega) = -\omega(N-1)/2 \text{ for } \omega \in \Omega_p \\ |H(\omega)| \le \beta \text{ for } \omega \in \Omega_s \end{array} \right\}.$$

where h is the impulse response of length N of the SIRF filter that shortens the impulse response of a channel, ω is a frequency, α and β are error tolerance regions of frequency and time domain, respectively, H(ω) is the impulse response in the frequency domain, R^N is the Hilbert space of dimension N, Ω_p is the pass-band, Ω_s is the stop-band, $A(\omega) = \sum_{0}^{N/2-1} 2h(n)\cos\left[\left(n - \frac{N-1}{2}\right)\omega\right]$ and $\Phi(\omega) = -\frac{N-1}{2}\omega$, wherein Φ(ω) and $A(\omega)$ are independent filter characteristics and wherein Φ(ω) is a linear phase and $A(\omega)$ is an amplitude.

9 (Cancelled)

10. The method according to claim 1, wherein said vector space projection method is iteratively applied to said at least one set of defining constraints that said SIRF filter must satisfy in the time domain and said at least one set of defining constraints that said SIRF

filter must satisfy in the frequency domain until the sets converge to a set of coefficients satisfying said time domain constraints and said frequency domain constraints.

11. A shortening impulse response filter (SIRF), comprising:

a set of finite impulse response (FIR) coefficients satisfying at least one constraint in a time domain and at least one constraint in a frequency domain, wherein said at least one time domain constraint is represented as at least one first set and wherein said at least one frequency domain constraint is represented as at least one second set, wherein said finite impulse response (FIR) coefficients are determined by an intersecting set of said at least one first set defining said time domain constraints and said at least one second set defining said frequency domain constraints, wherein said intersecting set is determined by employing vector space projection methods.

12. The SIRF according to claim 11, wherein said at least one first set defining constraints that said SIRF filter must satisfy in a time domain define a filter having a linear phase response.

13. The SIRF according to claim 11, wherein said at least one second set defining constraints that said SIRF filter must satisfy in a frequency domain define a filter having a non-linear phase response.

14. The SIRF according to claim 11, wherein the time domain constraints specify a shortening of a channel impulse response.

15. The SIRF according to claim 11, wherein the frequency domain constraints include a frequency response for said SIRF filter that does not attenuate a received signal.

16. The SIRF according to claim 11, wherein the frequency domain constraints include a pass-band for said SIRF filter.

17. (Cancelled)

18. The SIRF according to claim 11, wherein said vector space projection method is iteratively applied to said at least one first set defining said time domain constraints and said at least one second set defining said frequency domain constraints until the sets converge to a set of coefficients satisfying said time domain constraints and said frequency domain constraints.

19. A system for determining coefficient values for a shortening impulse response filter (SIRF), said system comprising:

a memory that stores computer-readable code; and

a processor operatively coupled to said memory, said processor configured to implement said computer-readable code, said computer-readable code configured to:

establish at least one set of defining constraints that said SIRF filter must satisfy in a time domain;

establish at least one set of defining constraints that said SIRF filter must satisfy in a frequency domain; and

determine an intersecting set of said at least one set of defining constraints that said SIRF filter must satisfy in the time domain and said at least one set of defining constraints that said SIRF filter must satisfy in the frequency domain by employing vector space projection methods.

20. The system according to claim 19, wherein said at least one set of defining constraints that said SIRF filter must satisfy in the time domain define a filter having a linear phase response.

21. The system according to claim 19, wherein said at least one set of defining constraints that said SIRF filter must satisfy in the frequency domain define a filter having a non-linear phase response.

22 The system according to claim 19, wherein the time domain constraints specify a shortening of a channel impulse response.

23. The system according to claim 19, wherein the frequency domain constraints include a frequency response for said SIRF filter that does not attenuate a received signal.

24. The system according to claim 19, wherein the frequency domain constraints include a pass-band for said SIRF filter.

25. The system according to claim 20, wherein said at least one set of defining constraints that the SIRF filter must satisfy in the frequency domain is defined as follows:

$$C_2 \equiv \left\{ \begin{array}{l} \mathbf{h} \in R^N : 1-\alpha \le \left|H(\omega)\right| \le 1+\alpha \ \text{ for } \omega \in \Omega_p \\ \text{and } \left|H(\omega)\right| \le \beta \text{ for } \omega \in \Omega_s \end{array} \right\}.$$

where h is the impulse response of length N of the SIRF filter that shortens the impulse response of a channel, ω is a frequency, α and β are error tolerance regions of frequency and time domain, respectively, H(ω) is the impulse response in the frequency domain, R^N is the Hilbert space of dimension N, Ω_p is the pass-band and Ω_s is the stop-band.

26. The system according to claim 21, wherein said at least one set of defining said domain constraints that the SIRF filter must satisfy in the frequency domain is defined as follows:

$$C_3 \equiv \left\{ \begin{array}{l} \mathbf{h} \in R^N : 1-\alpha \le A(\omega) \le 1+\alpha \\ \text{and } \Phi(\omega) = -\omega(N-1)/2 \ \text{ for } \omega \in \Omega_p \\ \left|H(\omega)\right| \le \beta \text{ for } \omega \in \Omega_s \end{array} \right\}.$$

where h is the impulse response of length N of the SIRF filter that shortens the impulse response of a channel, ω is a frequency, α and β are error tolerance regions of frequency and time domain, respectively, H(ω) is the impulse response in the frequency domain, R^N is the Hilbert space of

dimension N, Ω_p is the pass-band, Ω_s is the stop-band, $A(\omega)=\sum_{0}^{N/2-1} 2h(n)\cos\left[\left(n-\frac{N-1}{2}\right)\omega\right]$ and $\Phi(\omega)=-\frac{N-1}{2}\omega$, wherein $\Phi(\omega)$ and $A(\omega)$ are independent filter characteristics and wherein $\Phi(\omega)$ is a linear phase and $A(\omega)$ is an amplitude.

27. (Cancelled)

28. The system according to claim 19, wherein said vector space projection method is iteratively applied to said at least one set of defining constraints that said SIRF filter must satisfy in the time domain and said at least one set of defining constraints that said SIRF filter must satisfy in the frequency domain until the set of defining constraints that said SIRF filter must satisfy in the time domain converge to a set of coefficients satisfying said time domain constraints and the set of defining constraints that said SIRF filter must satisfy in the frequency domain converge to a set of coefficients satisfying said frequency domain constraints.

EVIDENCE APPENDIX

There is no evidence submitted pursuant to § 1.130, 1.131, or 1.132 or entered by the Examiner and relied upon by appellant.

RELATED PROCEEDINGS APPENDIX

There are no known decisions rendered by a court or the Board in any proceeding identified pursuant to paragraph (c)(1)(ii) of 37 CFR 41.37.